

Application of: Bishop, William M.  
Serial No.: 10/709,153  
PRELIMINARY AMENDMENT

### **AMENDMENTS TO THE CLAIMS**

This listing of claims will replace all prior revisions, and listings, of claims in the application.

1. (Currently Amended). A flexible natural gas storage facility comprising:
  - at least one man-made uncompensated salt cavern;
  - a pipeline source of a first fluid;
  - at least one high pressure compressor to compress the first fluid;
  - at least one heat exchanger to cool the first fluid from the compressor to a temperature that is compatible with the uncompensated salt cavern, before the first fluid is placed in the uncompensated salt cavern for storage;
  - a source of a second fluid;
  - at least one high pressure cryogenic pump to raise the pressure of the second fluid to dense phase; and
  - at least one Bishop Process™ heat exchanger to heat the second fluid to a temperature that is compatible with the uncompensated salt cavern, before the second fluid is placed in the uncompensated salt cavern for storage.

2. (Previously Presented). The apparatus of claim 1 wherein the source of the second fluid is a LNG transport ship.

3. (Previously Presented). The apparatus of claim 1 wherein the source of the second fluid is a conventional LNG receiving terminal.

4. (Currently Amended). The apparatus of claim 1 further including:  
a first uncompensated salt cavern to receive the compressed and cooled first fluid;  
a second uncompensated salt cavern to receive the pressurized and heated second fluid; and  
a third uncompensated salt cavern to receive portions of the compressed and cooled first fluid from the first uncompensated salt cavern and portions of the pressurized and heated second fluid from the second uncompensated salt cavern to adjust the Btu content of the blended fluids in the third uncompensated salt cavern.

5. (Currently Amended). The apparatus of claim 1 further including at least one booster compressor to compress the second fluid from the Bishop Process™ heat exchanger before the second fluid is placed in the uncompensated salt cavern for storage.

6. (Currently Amended). A flexible natural gas storage facility comprising:

at least one man-made uncompensated salt cavern;  
a pipeline source of a first fluid;  
at least one high pressure compressor to compress the first fluid;  
at least one heat exchanger to cool the first fluid from the compressor to a temperature that is compatible with the uncompensated salt cavern, before the first fluid is placed in the uncompensated salt cavern for storage;  
a source of a second fluid;  
at least one high pressure cryogenic pump to raise the pressure of the second fluid to dense phase; and  
at least one high pressure vaporizer to heat the second fluid to a temperature that is compatible with the uncompensated salt cavern, before the second fluid is placed in the uncompensated salt cavern for storage.

7. (Previously Presented). The apparatus of claim 6 wherein the source of the second fluid is a LNG transport ship.

8. (Previously Presented). The apparatus of claim 6 wherein the source of the second fluid is a conventional LNG receiving terminal.

9. (Currently Amended). The apparatus of claim 6 further including:

a first uncompensated salt cavern to receive the compressed and cooled first fluid;  
a second uncompensated salt cavern to receive the pressurized and heated second fluid; and  
a third uncompensated salt cavern to receive portions of the compressed and cooled first fluid from the first uncompensated salt cavern and portions of the second fluid from the second uncompensated salt cavern to adjust the Btu content of the blended fluids in the third uncompensated salt cavern.

10. (Currently Amended). A method of storing natural gas comprising:  
compressing a first fluid from a pipeline source of natural gas;  
cooling the compressed first fluid to a temperature that is compatible with a uncompensated salt cavern;  
injecting the cooled, compressed first fluid into at least one uncompensated salt cavern;  
pressurizing a second fluid from a LNG source to the dense phase;  
heating the second fluid in a Bishop Process™ heat exchanger to a temperature that is compatible with a uncompensated salt cavern;  
injecting the second fluid into the uncompensated salt cavern; and  
releasing the cooled, compressed first fluid and the second fluid from the uncompensated salt cavern into a pipeline for transport to market.

11. (Currently Amended). A method of storing natural gas comprising:

- compressing a first fluid from a pipeline and raising the pressure to dense phase;
- cooling the first fluid to a temperature that is compatible with a uncompensated salt cavern;
- injecting the first fluid into at least one uncompensated salt cavern;
- pressurizing a second fluid to the dense phase;
- heating the second fluid in a Bishop Process™ heat exchanger to a temperature that is compatible with a uncompensated salt cavern;
- injecting the second fluid into the uncompensated salt cavern; and
- releasing the first fluid and the second fluid from the uncompensated salt cavern into a pipeline for transport to market.

12. (Currently Amended). A method of storing natural gas comprising:

- compressing a first fluid from a pipeline source of natural gas;
- cooling the compressed first fluid to a temperature that is compatible with a uncompensated salt cavern;
- injecting the cooled, compressed first fluid into at least one uncompensated salt cavern;
- pressurizing a second fluid to the dense phase;

vaporizing the second fluid to raise the temperature to a temperature that is compatible with the uncompensated salt cavern;

injecting the second fluid into the uncompensated salt cavern; and

releasing the cooled, compressed first fluid and the second fluid from the uncompensated salt cavern into a pipeline for transport to market.

13. (Currently Amended). A method of storing natural gas comprising
- compressing a first fluid from a pipeline and raising the pressure to dense phase;
  - cooling the first fluid to a temperature that is compatible with a uncompensated salt cavern;
  - injecting the cooled, first fluid into at least one uncompensated salt cavern;
  - pressurizing a second fluid to the dense phase;
  - vaporizing the second fluid to raise the temperature to a temperature that is compatible with the uncompensated salt cavern;
  - injecting the second fluid into the uncompensated salt cavern; and
  - releasing the cooled, first fluid and the second fluid from the uncompensated salt cavern into a pipeline for transport to market.

14. (New). A flexible natural gas storage facility that receives LNG from an LNG tank source, the facility comprising:

at least one uncompensated salt cavern; and

at least one cryogenic pump to raise the pressure of the LNG from the source to the dense phase and move the dense phase fluid through at least one heat exchanger at sufficient velocity to result in a Froude Number of greater than 10, the heat exchanger raising the temperature of the dense phase fluid to a temperature that is compatible with the at least one uncompensated salt cavern, before at least a portion of the dense phase fluid is placed in the at least one uncompensated salt cavern for storage.

15. (New). The flexible natural gas storage facility of claim 14 further including a natural gas pipeline source and further including:

at least one compressor to compress the natural gas from the source; and

at least one heat exchanger to cool the compressed natural gas to a temperature that is compatible with the uncompensated salt cavern, before the compressed natural gas is placed in the at least one uncompensated salt cavern for storage.

16. (New). The flexible natural gas storage facility of claim 15 wherein:

the LNG in the tank source is kept at about 1 atmosphere of pressure.

17. (New). The flexible natural gas storage facility of claim 16 further including:

a first uncompensated salt cavern to store the fluid;  
a second uncompensated salt cavern to store the compressed natural gas; and  
a third uncompensated salt cavern to store and blend a portion of the fluid from the first uncompensated salt cavern with a portion of the compressed natural gas from the second uncompensated salt cavern to adjust the Btu content of the blended fluids to conform to a pre-established pipeline standard.

18. (New). The flexible natural gas storage facility of claim 14 further including at least one booster compressor to facilitate transfer of the dense phase fluid from the at least one heat exchanger to the at least one uncompensated salt cavern.

19. (New). The flexible storage facility of claim 16 wherein the heat exchanger has a pipe in pipe design with at least one inner conduit formed from cryogenically compatible material and a outer conduit is formed from material that is not cryogenically compatible, the inner conduit being of sufficient strength to contain the pressures of the dense phase fluid.

20. (New). The flexible natural gas storage facility of claim 16 wherein the heat exchanger is a vaporizer that is of sufficient strength to contain the pressures of the dense phase fluid.



21. (New). A flexible natural gas storage facility comprising:

- a source of LNG;
- at least one uncompensated salt cavern; and
- at least one cryogenic pump to move the LNG from the source through at least one vaporizer to raise the temperature of the LNG and convert it into a fluid with a temperature that is compatible with the uncompensated salt cavern, before at least a portion of the fluid is placed in the at least one uncompensated salt cavern for storage.

22. (New). The flexible natural gas storage facility of claim 21 further including:

- a source of natural gas;
- at least one compressor to compress the natural gas from the source; and
- at least one heat exchanger to cool the compressed natural gas to a temperature that is compatible with the uncompensated salt cavern, before the compressed natural gas is placed in the at least one uncompensated salt cavern for storage.

23. (New). The flexible natural gas storage facility of claim 22 wherein:

- the source of LNG is at least one tank and the source of natural gas is at least one pipeline.

24. (New). The flexible natural gas storage facility of claim 23 further including:

a first uncompensated salt cavern to store the fluid;  
a second uncompensated salt cavern to store the compressed natural gas; and  
a third uncompensated salt cavern to store and blend a portion of the fluid from the first uncompensated salt cavern with a portion of the compressed natural gas from the second uncompensated salt cavern to adjust the Btu content of the blended fluids to conform to a pre-established pipeline standard.

25. (New). The flexible natural gas storage facility of claim 21 further including at least one booster compressor to facilitate transfer of the fluid from the at least one vaporizer to the at least one uncompensated salt cavern.

26. (New). A flexible natural gas storage facility comprising:  
a facility to secure at least one transport ship carrying a cryogenic liquid;  
a first stage pumping system with sufficient pressure and volume to offload the cryogenic liquid from the transport ship and store at least a portion of the liquid in at least one tank;  
a second stage pumping system raising the pressure of the cryogenic liquid to convert the cryogenic liquid into a dense phase fluid, the second stage pumping system also providing sufficient pressure and volume to move the dense phase fluid through at least one heat exchanger; and

the at least one heat exchanger warming the dense phase fluid to a temperature compatible with at least one uncompensated salt cavern, before at least a portion of the dense phase fluid is placed in the at least one salt cavern for storage.

27. (New). The flexible natural gas storage facility of claim 26 further including:

at least one compressor to compress natural gas from at least one pipeline;

at least one heat exchanger to cool the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern, before the compressed natural gas is placed in the at least one uncompensated salt cavern for storage.

28. (New). The flexible natural gas storage facility of claim 27 further including:

a first uncompensated salt cavern to store the fluid;

a second uncompensated salt cavern to store the compressed natural gas; and

a third uncompensated salt cavern to store and blend a portion of the fluid from the first uncompensated salt cavern with a portion of the compressed natural gas from the second uncompensated salt cavern to adjust the Btu content of the blended fluids to conform to a pre-established pipeline standard.

29. (New). The flexible natural gas storage facility of claim 26 further including at least one booster compressor to facilitate transfer of the dense phase fluid from the at least one heat exchanger to the at least one uncompensated salt cavern.

30. (New). A flexible natural gas storage facility comprising:

- a mooring/docking facility for a least one LNG transport ship;
- at least one tank to receive at least a portion of the LNG from the transport ship;
- at least one high pressure pumping system raising the pressure of the LNG to convert the LNG into dense phase natural gas (DPNG ), the high pressure pumping system also providing sufficient pressure to move the DPNG through at least one heat exchanger and transfer at least a portion of the DPNG into a least one uncompensated salt cavern; and

the at least one heat exchanger warming the DPNG to a temperature compatible with the at least one uncompensated salt cavern.

31. (New).The flexible natural gas storage facility of claim 30 further including:

- at least one compressor to compress natural gas from at least one pipeline;
- at least one heat exchanger to cool the compressed natural gas to a temperature that is compatible with the uncompensated salt cavern, before the compressed natural gas is placed in the at least one uncompensated salt cavern for storage.

32. (New). The flexible natural gas facility of claim 31 further including:

- a first uncompensated salt cavern to store the DPNG;
- a second uncompensated salt cavern to store the compressed natural gas; and
- a third uncompensated salt cavern to store and blend a portion of the DPNG from the first uncompensated salt cavern with a portion of the compressed natural gas from the second uncompensated salt cavern to adjust the Btu content of the blended fluids to conform to a pre-established pipeline standard.

33. (New). The flexible natural gas storage facility of claim 30 further including at least one booster compressor to facilitate transfer of the dense phase fluid from the at least one heat exchanger to the at least one uncompensated salt cavern.

34. (New). A flexible natural gas storage facility comprising:

- a mooring/docking facility for at least one transport ship carrying at least one cryogenic liquid;
- at least one tank to receive at least a portion of the cryogenic liquid from the transport ship;
- a high pressure pumping system raising the pressure of the cryogenic liquid to convert the cryogenic liquid into dense phase fluid, the high pressure pumping system also providing sufficient pressure to move the dense phase fluid through at least one heat exchanger,

the heat exchanger warming the dense phase fluid to a temperature compatible with at least one uncompensated salt cavern, before at least a portion of the warmed dense phase fluid is placed in the at least one uncompensated salt cavern for storage.

35. (New). The flexible natural gas storage facility of claim 34 further including:  
at least one compressor to compress natural gas from at least one pipeline;  
at least one heat exchanger to cool the compressed natural gas to a temperature that is compatible with the uncompensated salt cavern, before the compressed natural gas is placed in the uncompensated salt cavern for storage.

36. (New). The flexible natural gas storage facility of claim 35 further including:  
a first uncompensated salt cavern to store the fluid;  
a second uncompensated salt cavern to store the compressed natural gas; and  
a third uncompensated salt cavern to store and blend a portion of the fluid from the first uncompensated salt cavern with a portion of the compressed natural gas from the second uncompensated salt cavern to adjust the Btu content of the blended fluids to conform to a pre-established pipeline standard.

37. (New). The flexible natural gas storage facility of claim 34 further including at least one booster compressor to facilitate transfer of the dense phase fluid from the at least one heat exchanger to the at least one uncompensated salt cavern.

38. (New). A flexible method of storing natural gas comprising:

pumping and pressurizing LNG from a tank so it becomes a dense phase fluid and moves through at least one heat exchanger resulting in a Froude Number in excess of 10;

heating the dense phase fluid in the at least one heat exchanger to a temperature that is compatible with at least one uncompensated salt cavern; and

transferring at least a portion of the warmed dense phase fluid into the at least one uncompensated salt cavern.

39. (New). The flexible method of claim 38 further including:

compressing natural gas;

cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and

storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

40. (New). A flexible method of storing natural gas comprising:

securing at least one transport ship carrying a cryogenic liquid to a mooring/docking facility;

receiving the cryogenic liquid from the transport ship and transferring at least a portion of the cryogenic liquid to at least one tank;

pumping the cryogenic liquid, at sufficient pressure to convert the liquid into a dense phase fluid, through at least one heat exchanger resulting in a Froude Number in excess of 10, where the dense phase liquid is warmed to a temperature that is compatible with at least one uncompensated salt cavern; and

transferring at least a portion of the warmed dense phase fluid into the at least one uncompensated salt cavern.

41. (New). The flexible method of claim 40 further including:

compressing natural gas from a pipeline source;

cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and

storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

42. (New). A flexible method of storing natural gas comprising;

securing at least one transport ship to a mooring/docking facility, the ship



carrying a cryogenic liquid;

receiving the cryogenic liquid from at least one ship and transferring at least a portion of the cryogenic liquid to at least one tank;

pumping the cryogenic liquid through at least one conventional vaporizer system where the liquid changes to a warmed fluid that has been warmed to a temperature that is compatible with at least one uncompensated salt cavern, the vaporizer system being reinforced to withstand the pressures of the pumping system; and

transferring at least a portion of the warmed fluid into the at least one uncompensated salt cavern.

43. (New). The flexible method of claim 42 further including:

compressing natural gas from a pipeline source;

cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and

storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

44. (New). A flexible method of storing natural gas comprising:

securing at least one transport ship with an LNG cargo to a mooring/docking facility;

receiving the LNG from the at least one ship and transferring at least a portion of the LNG from the ship to at least one tank;

pumping the LNG, at sufficient pressure to convert the LNG into dense phase natural gas (DPNG), through at least one heat exchanger where the DPNG is warmed to a temperature that is compatible with at least one uncompensated salt cavern; and

transferring at least a portion of the warmed DPNG into the at least one uncompensated salt cavern.

45. (New). The flexible method of claim 44 further including:

compressing natural gas from a pipeline source;

cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and

storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

46. (New). A flexible method of storing and discharging natural gas comprising:

securing at least one transport ship with an LNG cargo to a mooring/docking facility;

receiving the LNG from the at least one ship and transferring at least a portion of the LNG into at least one tank;

transferring the LNG to at least one high pressure pumping system;  
pumping the LNG, at sufficient pressure to convert the LNG into dense phase natural gas (DPNG), through at least one heat exchanger where the DPNG is warmed to a temperature that is compatible with at least one uncompensated salt cavern;  
transferring at least a portion of the warmed DPNG into at least one uncompensated salt cavern; and  
discharging at least a portion of the DPNG from the uncompensated salt cavern through a pipeline to a market.

47. (New). The flexible method of claim 46 further including:

compressing natural gas from a pipeline source;  
cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and  
storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

48. (New). A flexible method of storing natural gas comprising:

securing at least one transport ship carrying a cryogenic liquid to a mooring /docking facility;  
receiving the cryogenic liquid from the at least one ship and transferring at least a

portion of the cryogenic liquid to at least one tank;

transferring the cryogenic liquid to at least one high pressure pumping system;

pumping the cryogenic liquid, at sufficient pressure to convert the liquid into a dense phase fluid, through at least one heat exchanger to warm the dense phase fluid to a temperature that is compatible with at least one uncompensated salt cavern, the heat exchanger having a pipe in pipe design with at least one inner conduit formed from cryogenically compatible material and an outer conduit formed from material that is not cryogenically compatible, the inner conduit being of sufficient strength to contain the pressures of the dense phase fluid;

transferring at least a portion of the warmed dense phase fluid into at least one uncompensated salt cavern.

49. (New). The flexible method of claim 48 further including:

compressing natural gas from a pipeline source;

cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and

storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

50. (New). A flexible method of storing and discharging natural gas comprising:

securing at least one transport ship carrying a cryogenic liquid to a mooring/docking facility;

receiving the cryogenic liquid from the at least one ship and transferring at least a portion of the cryogenic liquid to at least one tank;

transferring the cryogenic liquid to at least one high pressure pumping system;

pumping the cryogenic liquid, at sufficient pressure to convert the liquid into a dense phase fluid, through at least one heat exchanger to warm the dense phase fluid to a temperature that is compatible with at least one uncompensated salt cavern, the heat exchanger having a pipe in pipe design with at least one inner conduit formed from cryogenically compatible material and an outer conduit formed from material that is not cryogenically compatible, the inner conduit being of sufficient strength to contain the pressures of the dense phase fluid;

transferring at least a portion of the warmed dense phase fluid into at least one uncompensated salt cavern; and

discharging at least a portion of the warmed dense phase fluid from the uncompensated salt cavern through a pipeline to a market.

51. (New). The flexible method of claim 50 further including:

compressing natural gas from a pipeline source;

cooling the compressed natural gas to a temperature that is compatible with the at

least one uncompensated salt cavern; and

storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

52. (New). A flexible method of storing natural gas comprising:

securing at least one ship carrying LNG to a mooring/docking facility;

receiving the LNG from the ship and transferring at least a portion of the LNG into at least one tank;

transferring the offloaded LNG to a pumping system;

pumping the LNG through at least one vaporizer system where the fluid is warmed to a temperature that is compatible with at least one uncompensated salt cavern; and

transferring at least a portion of the warmed fluid into at least one uncompensated salt cavern.

53. (New). The flexible method of claim 52 further including:

compressing natural gas from a pipeline source;

cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and

storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

54. (New). A flexible method of storing natural gas comprising:

- securing at least one transport ship carrying a cryogenic fluid to a mooring/docking facility;
- receiving the cryogenic fluid from the ship and transferring at least a portion of the cryogenic fluid to at least one tank;
- pumping the cryogenic fluid through at least one conventional vaporizer where the fluid is warmed to a temperature that is compatible with at least one uncompensated salt cavern; and
- transferring at least a portion of the warmed fluid into at least one uncompensated salt cavern.

55. (New). The flexible method of claim 54 further including:

- compressing natural gas from a pipeline source;
- cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and
- storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

56. (New). A flexible method of storing natural gas comprising:

securing at least one transport ship to a mooring/docking facility, the ship  
carrying LNG;

offloading at least a portion of the LNG from the ship to at least one tank;

transferring the cryogenic liquid from the at least one tank to a high pressure  
pumping system;

pumping the cryogenic liquid, at sufficient pressure to convert the cryogenic  
liquid into a dense phase fluid, through a conventional vaporizer system where the dense phase  
fluid is warmed to a temperature that is compatible with at least one uncompensated salt cavern,  
the conventional vaporizer system being modified and strengthened to withstand the high  
pressure of the dense phase fluid from the high pressure pumping system; and

transferring at least a portion of the warmed dense phase fluid into the at least one  
uncompensated salt cavern.

57. (New). The flexible method of claim 56 further including:

compressing natural gas from a pipeline source;

cooling the compressed natural gas to a temperature that is compatible with the at  
least one uncompensated salt cavern; and

storing the cooled, compressed natural gas in the at least one uncompensated salt  
cavern.



58. (New). A flexible method of storing natural gas comprising:

- securing at least one transport ship to a mooring/docking facility, the ship carrying a cryogenic liquid;
- offloading at least a portion of the cryogenic liquid from the ship to at least one tank;
- transferring the cryogenic liquid to at least one pumping system;
- pumping the cryogenic liquid, at sufficient pressure to convert the cryogenic liquid into a dense phase fluid, through at least one conventional vaporizer system where the dense phase fluid is warmed to a temperature that is compatible with at least one uncompensated salt cavern, the conventional vaporizer system being modified and strengthened to withstand the high pressure of the dense phase fluid from the pumping system; and
- transferring at least a portion of the warmed dense phase fluid into the uncompensated salt cavern.

59. (New). The flexible method of claim 58 further including:

- compressing natural gas from a pipeline source;
- cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and
- storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

60. (New). A flexible method of storing natural gas comprising:

pressurizing LNG to a pressure that will keep the LNG outside of the two phase envelope and change the LNG into dense phase natural gas (DPNG);

warming the DPNG in at least one heat exchanger to a temperature that is compatible with at least uncompensated salt cavern; and

transferring at least a portion of the warmed, DPNG into at least one uncompensated salt cavern.

61. (New). The flexible method of claim 60 further including:

compressing natural gas from a pipeline source;

cooling the compressed natural gas to a temperature that is compatible with the at least one uncompensated salt cavern; and

storing the cooled, compressed natural gas in the at least one uncompensated salt cavern.

62. (New). A flexible method of claim 61 further including:

discharging the DPNG from the at least one uncompensated salt cavern through a pipeline to market.